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THESIS

A NAVAL MARKSMANSHIP TRAINING TRANSFER STUDY: THE USE OF INDOOR SIMULATED MARKSMANSHIP TRAINERS TO TRAIN FOR LIVE FIRE

by

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March 2012

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13. ABSTRACT (maximum 200 words)

The use of simulation to train watchstanders in marksmanship would provide a valuable and flexible training asset to the Navy, resulting in minimal lost training opportunities due to operational commitments at sea. We hypothesized that (1) simulation-based marksmanship training would transfer to live fire better than dry fire training, and (2) the experimental (simulation) group would have a better chance of retaining their marksmanship skills than the control group after two or four weeks with no instruction.

Thirty-four active duty military volunteers were randomly assigned to receive either simulation training using the Indoor Simulated Marksmanship Trainer (ISMT) or standard naval marksmanship training and given either a two- or four-week gap between training and final live fire events. Main measures of marksmanship performance were mean point of impact (MPI) of group shots and scores on the standard Navy Handgun Qualification Course.

Results partially supported the hypotheses. The simulation group showed greater improvement in MPI than the control group from baseline to live fire. However, no significant differences were found between the two- and four-week gaps in either case tested, suggesting a longer time gap is needed to test skill retention. Results suggest that simulation training is as effective as standard navy marksmanship training and would benefit the Navy to incorporate ISMT as an at-sea marksmanship trainer.

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A NAVAL MARKSMANSHIP TRAINING TRANSFER STUDY: THE USE OF INDOOR SIMULATED MARKSMANSHIP TRAINERS TO TRAIN FOR LIVE FIRE

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LIST OF ACRONYMS AND ABBREVIATIONS

CO_2	Carbon Dioxide
ISMT	Indoor Simulated Marksmanship Trainer
IRB	Institutional Review Board
LTC	Lieutenant Colonel
M16	5.56mm service rifle
M2	.50 caliber machine gun
M240	7.62mm machine gun
M9	9mm Berretta
MPI	Mean Point of Impact
NHQC	Navy Handgun Qualification Course
NPS	Naval Postgraduate School
RSO	Range Safety Officer
SNMT	Standard Navy Marksmanship Training
Transtar II	U.S. Treasury Transitional Target
U.S.	United States
USMC	United States Marine Corps

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I. INTRODUCTION

A. PROBLEM STATEMENT

The Navy has access to 41 Indoor Simulated Marksmanship Trainers (ISMTs). The authors informally interviewed approximately 50 Navy officers with recent experience in Fleet concentration areas where the Navy ISMT systems are located and only one knew of the existence of ISMT. This suggests that the Navy does not adequately communicate the availability of ISMT to sailors in the Fleet. As a result, many commands, both at sea and ashore, do not take advantage of training watchstanders with ISMT, but instead rely on standard Navy marksmanship training (SNMT). According to the Department of the Navy's Small Arms Training and Qualification instruction, OPNAVINST 3591.1F (Chief of Naval Operations, 2009, Enclosure 3, 1):

> All personnel must requalify with live fire annually. All personnel are also required to undergo semi-annual sustainment training between qualification shoots, not to exceed 8 months after live fire qualification. If available, sustainment training shall be completed on a simulator.

Oftentimes requalification and sustainment training are based on operational requirements, resulting in lost training opportunities. Currently, most watchstanders only handle a firearm when they check in and out of the armory which is typically two to three times a month on duty days. The training currently being used by the Navy focuses on how to properly respond to a force protection threat, but assumes the watchstander knows how to properly use a firearm based on dry fire and PowerPoint training. This assumption leads to a concern that personnel may know the required actions, but may not have the marksmanship skills required to effectively employ their weapon.

The concept is simple: until a person has received enough practice discharging rounds down range to reach the required level of accuracy and proficiency, it is not certain that they will be effective with firearms during an actual force protection situation (Getty, 2008). A force protection situation is any instance in which personnel or organizations intend to advance their political agenda against the United States (U.S.) by harming U.S. assets (Naval Surface Forces Command, 2008). Effective use of a firearm

is an extremely important factor in suppressing a threat if a force protection situation is detected. Navy personnel are trained to make the proper announcements to alert the crew and give the proper commands to deal with an attacker, but if the watchstander cannot hit the target when required, then the entire antiterrorism and force protection training system fails.

Currently, the Navy marksmanship training program teaches fundamental marksmanship skills via dry fire and PowerPoint to all watchstanders and includes antiterrorism and force protection training that incorporates real-world-type scenarios, but uses mock weapons. A small number of shipboard watchstanders receive specialized training as a reaction force, to include Ship's Reactionary Force Advanced training, to combat various shipboard threat situations. Visit Board Search and Seizure teams get more advanced real-world, scenario-type training to include role playing and paint ball, but accounts for only a small number of service members. The use of simulation to train watchstanders is minimally used, but would provide a valuable and flexible training asset to the Navy, resulting in minimized lost training opportunities due to operational commitments. It is reasonable to believe that personnel would be more likely to protect the ship during an attack if commands regularly utilized available simulators or placed simulators onboard ships so that personnel could practice their marksmanship skills on a regular basis.

B. STUDY PURPOSE

This thesis explores whether simulation-based marksmanship training with the ISMT transfers to live fire, and also attempts to provide insight into how long any beneficial effects of simulation training last. This research also investigates whether the use of simulation, combined with live fire, can provide a more robust method than SNMT. The course of fire used in this thesis was the standard Navy Handgun Qualification Course (NHQC) firing sequence defined in OPNAVINST 3591.1F (Chief of Naval Operations, 2009). By providing the means to practice a perishable skill like marksmanship, the Navy may have fewer incidents or casualties (Getty, in progress). The research questions addressed in this thesis are:

- Does ISMT result in skill transfer from the virtual environment to actual proficiency in marksmanship performance?
- Can ISMT be used as an effective part-task trainer to improve performance with the 9mm Berretta (M9) on the NHQC? Specifically: Will participants in the experimental (simulation) group have a better chance of retaining what they learned after two weeks or four weeks of no instruction, than participants in the control group (SNMT) when doing live fire?

C. LITERATURE REVIEW

With the increased operational tempo, ships are going out to sea more frequently. According to *Navy Times*, deployments that were traditionally six months in duration have now increased to between 8 and 10 months (Faram et al., 2012). Given that deployments now entail at least eight months, it is often difficult for personnel to maintain current sustainment requirements. More time at sea means less time in port for personnel to train in basic skills like marksmanship. In order to meet the scheduling demands and operational commitments at sea, oftentimes operational requirements prevent any type of topside marksmanship training while at sea. The Navy currently does not have marksmanship simulators onboard ships, but having an onboard simulator within the skin of the ship could allow personnel to circumvent the necessity to go topside to conduct marksmanship training and provide an opportunity to train basic marksmanship skills at sea.

Little is known about how ISMT training transfers to live fire. LTC Yates, United States Marine Corps (USMC), studied the effectiveness of the ISMT to train Marines in marksmanship fundamentals (2004). Using 28 participants at Marine Corps Recruit Depot, San Diego during the initial rifle qualification using the USMC course of fire, a side-by-side comparison was conducted to measure the performance of Marines trained in ISMT compared to Marines who were trained using dry fire, culminating in a final live fire qualification. The results showed no significant difference in group shots and scores; in other words, the Marines who trained with ISMT performed as well as those who trained without ISMT. LTC Yates concluded that there was a lack of evidence to support

ISMT being used as the only training mechanism without also providing expert instruction. The importance of this study was that the ISMT training was as effective as dry fire.

The U.S. Army Research Laboratory conducted a training transfer study, *A Comparison of Live and Simulated Fire Soldier Shooting Performance* (ARL-TR-4234, 2007), using the Dismounted Infantry Survivability and Lethality Testbed simulation-based training to determine the transfer to live training. Twelve participants completed a course of fire using the M16 to fire at 18 pop-up target silhouettes. Firing ranges consisted of 75-, 100-, 150-, 200-, 250-, and 300-meter targets from a kneeling, foxhole-supported position. Each participant was exposed to 10 trials of simulation and live fire, and hit percentage, shot reaction time, shooting performance, and radial aiming error were assessed under both conditions. Both simulation and live fire showed similar hit percentages, indicating that participants' maintained performance from simulation to live fire. In live fire, each shot took less time and reaction times were faster compared to the shots and reaction times in the simulation. The difference in reaction times may be attributed to many factors including human attributes such as rifle movement with a live weapon or outside weather conditions. The notion that there is a strong relationship between basic marksmanship skills in simulation and live fire is supported by this research.

The Army Research Institute for the Behavioral and Social Sciences' Research Report 1761 (2000) compared simulated marksmanship training to standard Army instruction with a final live fire qualification course of fire. One hundred eighty-four participants trained with simulation, while two hundred two participants trained with standard Army instruction. All participants completed 11 periods of instruction, ranging from introduction to basic rifle marksmanship and mechanical training to practice firing, leading up to firing for qualification. The dependent variables were the number of targets hit and rounds fired during training and qualification fire. Results indicated that the use of simulation for basic rifle marksmanship training reduced the number of live rounds fired, increased the number of participants firing to standard requirements, and increased the number of target hits. Simulation did not improve record fire qualification scores.

The results of the Research Report 1761 (Army Research Institute for the Behavioral and Social Sciences, 2000) suggest that simulation-based marksmanship training would improve initial entry rifle marksmanship performance, while saving ammunition.

The above studies have addressed Marine or Army marksmanship training; there has been very little research directed at Navy marksmanship training, specifically with a time gap between training and qualification course of fire. Getty (2008) compared simulation marksmanship training using the ISMT to SNMT with a one-week gap between training and qualification course of fire. A between-groups study was conducted with random selection of participants blocked by previous marksmanship experience in which half of the participants received training in the ISMT, while the other half received SNMT. The dependent variables were diameter size of average group shots, diameter size of group shots and length of mean point of impact to center zeroing point for the 3-, 7-, and 15-yard lines, and overall scores on the NHQC course of fire. Getty's findings show there was no change in participants' marksmanship performance and scores regardless of whether they received the ISMT training or the SNMT, except for the 7-yard line. For the 7-yard line, participants who received the ISMT training showed greater improvements in performance than participants who received SNMT. Exploratory analyses suggest that simulation training may be most beneficial for less experienced shooters. Additionally, there was no significant difference in skill retention after one week between the ISMT participants and SNMT participants, suggesting that a longer period of time is needed to detect group differences in the retention of skills.

In summary, the studies by LTC Yates (2004), ARL-TR-4234 (U.S. Army Research Laboratory, 2007), and Research Report 1761 (U.S. Army Research Institute for the Behavioral and Social Sciences, 2000) show that simulation is at least as effective in marksmanship training as current standard Army and Marine marksmanship training and can be a cost-effective way to train. What is not known is the effect that simulation-based training has on live fire compared to the effects of SNMT. The main difference between Navy, Marine, and Army marksmanship training is the weapon that is being fired, the distance fired, and the rate of fire. In addition, Getty (2008) attempted to compare simulation training to SNMT, with only a one-week gap between training and

qualification course of fire. It is still not known how long any beneficial effects last from simulation-based training to live fire. Thus, the purpose of this thesis was to attempt to address these two important gaps in knowledge.

D. OBJECTIVES

Currently, the Navy has access to 41 ISMT simulators, of which none are onboard ship. The existence of the ISMT simulators is not well communicated and simulation is not used to its fullest capacity, which results in many lost training opportunities. With no simulators located onboard ship, marksmanship training is dependent on operational requirements while at sea and is often neglected due to other shipboard evolutions such as flight or wet well operations. As a result, shipboard personnel may not receive required sustainment training, thus weakening the ship's first line of defense—watchstanders.

The objective of this thesis was to determine if the use of simulation, combined with live fire, can provide a more robust method than SNMT for effectively training watchstanders. ISMT was used as a part task trainer to teach basic marksmanship skills to the experimental group, while dry fire was used to teach basic marksmanship skills to the control group, immediately followed by the NHQC firing sequence in ISMT by both groups. With either a two-week or four-week gap after training, all participants completed a live fire event consisting of the NHQC firing sequence. Main measures of marksmanship performance were MPI of group shots and scores from the NHQC firing sequence.

E. RESEARCH QUESTIONS AND HYPOTHESES

1. Question One

Does the ISMT accomplish skill transfer from the virtual environment to actual live fire proficiency in marksmanship performance?

$H0_1$: There will be no group differences in the participants' MPI of shots and scores in the NHQC firing sequence from baseline to live fire event.

HA_1: Participants who receive simulation-based training in ISMT will have a greater improvement in MPI of shots and scores in the NHQC firing sequence when comparing the difference between baseline and live fire than participants who receive SNMT.

2. Question Two

Can the ISMT be used as an effective part-task trainer to improve performance with the M9 on the NHQC? Specifically, will participants in the simulation group have a better chance of retaining what they learned after two weeks or four weeks of no instruction, than participants in the control group, when performing live fire?

$H0_2$: Participants in each group will be equally likely to maintain their MPI of shots and scores on the NHQC two weeks and four weeks after the training day.

HA_2: Participants who receive simulation-based training in ISMT will be more likely than those in the control group to maintain their MPI of shots and scores in the NHQC two weeks and four weeks after the training day.

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II. METHOD

A. OVERVIEW OF RESEARCH DESIGN

This thesis closely follows the procedures used by Getty (2008). Getty's experiment explored whether simulation-based marksmanship training with the ISMT improved marksmanship performance to a greater extent than SNMT. A between-groups study, with a random selection of volunteers (blocked by previous marksmanship experience), was conducted. The independent variables were the two different training programs. The control group received SNMT that covered fundamentals of marksmanship, followed by untimed dry fire, a practice qualification that implemented time limits. The simulation group received marksmanship training enhanced by simulation of the feedback that ISMT provides (Getty, 2008).

The experimental design for this thesis utilized a between-groups study of active duty military volunteers randomly selected to complete either SNMT for the control group or simulation training conducted using the system feedback provided from ISMT for the simulation group. Marksmanship performance was measured by MPI and score using the NHQC firing sequence. This thesis research was approved by the Naval Postgraduate School (NPS) Institutional Review Board (IRB); IRB approval number NPS.2011.0102-IR-CONV-A.

B. PARTICIPANTS

All participants were active duty U.S. military members and all were either students or faculty at NPS. A total of 34 participants, 17 in the simulation group and 17 in the control group, took part in this study. Of the 34 initial participants, 33 completed the pre-training demographics survey. Tables 1 and 2 characterize the simulation and control group participants' general demographic and previous marksmanship experience. Of note, no significant differences between simulation and control groups were found for any demographic or previous marksmanship experience items.

Table 1. General Statistics from Participants' Demographic Surveys

Demographics Survey (General)		Control	Simulation
Age (%):	**Years**		
	24–29	19	24
	30–36	31	35
	37–41	31	35
	42+	19	6
Gender (%):			
	Male	94	94
	Female	6	6
Corrected Vision (%):			
	Yes	38	12
	No	62	88
Height (in):			
	Mean	70.38	69.47
	Standard Deviation	2.42	2.00
Weight (lbs):			
	Mean	190.69	186.29
	Standard Deviation	27.56	17.43
Years of Service:			
	Mean	13.66	11.79
	Standard Deviation	7.92	4.83
Branch of Service (%):			
	Army	0	18
	Navy	68	76
	Air Force	13	6
	Marines	13	0
	Coast Guard	6	0
Pay Grade (%):			
	E-5	6	6
	0–2	6	0
	0–3	50	53
	0–4	13	17
	0–5	13	24
	0–6	12	0
Job Specialty (%):			
	Surface Warfare	13	24
	Aviation	25	24
	Ground Element	0	11
	Intelligence	31	29
	Engineering	31	12

The general information gathered from the demographic surveys showed no significant differences between the control and simulation groups in any of the characteristics collected (based on two-tailed $\alpha = 0.05$, all $p > 0.118$).

Table 2. Firearm Specific Statistics from Participants' Demographic Surveys

Demographics Survey (Firearms)	**Control**	**Simulation**
Dominant Shooting Hand (%):		
Ambidextrous	6	6
Right	88	88
Left	6	6
Self-Reported Proficiency (%):		
Novice	19	23
Marksman	38	29
Sharpshooter	13	24
Expert	31	24
Last Fired a Weapon (Years):		
Mean	3.20	1.35
Standard Deviation	7.73	1.45
Earliest	Jun 80	Jun 07
Latest	Nov 11	Oct 11
Formal Marksmanship Training (%):		
Yes	81	76
No	19	24
Last Formal Training (Years):		
Mean	8.66	6.06
Standard Deviation	11.49	5.39
Earliest	Jun 80	Jul 95
Latest	May 11	Oct 11
Performance on Last Qualification (%):		
Never Shot for Qualification	6	12
Marksman	6	6
Sharpshooter	13	23
Expert	75	59
Last Qualification (Years):		
Mean	6.28	4.78
Standard Deviation	8.71	4.34
Earliest	Jun 80	Jan 97
Latest	May 11	Mar 11

The firearm-specific information gathered from the demographic surveys shows no significant differences between the control and simulation groups in any of the characteristics collected (based on two-tailed $\alpha = 0.05$, all $p > 0.180$).

C. EQUIPMENT

1. ISMT

ISMT is currently employed by the USMC as a portable, stand-alone marksmanship trainer. ISMT is a "three dimensional simulation based trainer for indoor use, capable of instructing in basic and advanced marksmanship, shoot/no-shoot judgment, combat marksmanship, and weapons employment tactics" (U.S. Marine Corps Concepts in Programs, 2008, p. 214). ISMT has the capability to use a wide variety of weapons, including the .50cal. machinegun (M2), 9mm Beretta (M9), 5.56mm service rifle (M16), 7.62mm machinegun (M240), and many more. The ISMT located at NPS can train up to two individuals at a time. ISMT has the unique capability to "provide immediate feedback to the instructor and trainee on weapon trigger pull, cant position, barrel movement, rifle butt pressure, tracing of the muzzle on a weapon prior to and after shoot, and grouping" (Getty, in progress, p. 3). Immediate feedback is vital in marksmanship training because it provides the opportunity for participants to adjust the weapon accordingly, thereby greatly improving accuracy. Just as important, ISMT records muzzle movement and displays the recording as part of the trace profile feature. The trace profile feature records 0.2 seconds before the trigger squeeze, the actual trigger squeeze, and 0.2 seconds post trigger squeeze. The data displayed from the trace profile feature allows the instructor to critique the participant's technique, which would be nearly impossible to do via the naked eye.

The ISMT lab is located in a 30-foot trailer on the NPS campus. The front section of the trailer contains the stored weapons and two Windows-based computers that run the ISMT. The weapons used in this research were tethered to the CO_2 cylinder bank and the ISMT operating system, with input leads consisting of a hose for CO_2 and a wire harness to provide audio and system feedback. The main section of the trailer contains the instructor control panel and the instructor's personal laptop, just forward of the firing line. The instructor's laptop is connected to two small speakers mounted just behind the

firing line in order to play the recorded training instructions. Also behind the firing line is the CO_2 cylinder bank that provides the recoil for the weapons. The projector that displays the video for the scenario and the camera that reads the laser from the weapons are mounted on the ceiling in the main section of the trailer. The large projector screen that displays the scenarios and the subwoofers that provide audio for realistic weapon firing sound effects are located at the end of the trailer.

2. Live Fire Equipment

In order to complete the live fire portion of this thesis, the following equipment was used: six M9s, six belts with holsters and magazine pouches, 36 magazines (six per weapon to facilitate the firing sequence), three belts with holsters and magazine pouches for ISMT, 2,000 rounds of ammunition, 96 blue U.S. Treasury Transitional Targets (Transtar II) for the live fire event, and eye and hearing protection for each participant.

Live fire was completed at the Laguna Seca Peace Corps Range. The range is outdoors and offers 25 lanes. Mandatory personal protective equipment, including eye protection (side shielded/wraparound), hearing protection (plugs/muffs), and protective clothing (long sleeves), was worn by all participants while participating in the live fire event. Two hospitals, Community Hospital of the Monterey Peninsula and Salinas Valley Memorial Hospital, were in close proximity to the Laguna Seca Pistol Range to address any medical incident that may have arisen during this study. The NPS IRB assigned a medical monitor to this study to address any medical situation. The medical monitor acted as military medical liaison to the IRB and NPS chain of command in the event a participant was injured. Participants were required to perform all safety procedures, demonstrate how to properly load and reload the weapon, and perform immediate actions in the event of a weapon malfunction prior to the live fire event. One Range Safety Officer (RSO) was present and controlling the range during the live fire event and provided a safety brief to participants prior to the event.

D. MEASURES

1. Demographics

A general demographics survey was administered, which contained questions about such topics as age, service, pay grade, and gender (see Table 1).

2. Marksmanship Experience Survey

A survey was administered that asked questions regarding participants' previous marksmanship experience (see Table 2).

E. ISMT SCENARIOS

The ISMT system used for this research was a USMC version and contained only USMC-approved scenarios. The three ISMT scenarios (zeroing, unlimited practice, and qualification NHQC firing sequence) that were used for this research were designed by Tommy Getty for a previous study. For more information on the design and settings used for each scenario, see Getty (2008).

1. Zeroing Scenario

First, the zeroing scenario was used to calibrate the M9 prior to the unlimited practice and NHQC firing sequence scenarios for both the control and simulation groups. This scenario had no time limit and provided only three rounds in the magazine. Participants were required to shoot three rounds center target at three yards in order to calibrate the M9 to the ISMT system. Making sure the M9 was properly calibrated ensured the accuracy of the weapon. The zeroing scenario was also used to complete operational testing of the M9 and aided in troubleshooting the weapon. No data was collected from this scenario.

2. Unlimited Practice Scenario

The unlimited practice scenario provided each participant with the opportunity to practice firing the M9 with unlimited rounds and no time restrictions. This scenario consisted of Transtar II silhouette targets at the 3-, 7-, and 15-yard lines, simultaneously displayed. The participants in the control group used this scenario as a means to conduct

dry fire. To facilitate a dry fire environment, the ISMT unlimited practice screen was displayed, but the M9 was disconnected from the system and CO_2 cylinder so there was no feedback from the system. The only feedback provided to participants in the control group was from the instructor. For participants in the simulation group, the M9 was connected to the ISMT system to provide system and audio feedback of shots fired and CO_2 cylinder to simulate recoil for the weapon. The instructor's control panel was turned toward the participant, allowing the participant to see the system-generated feedback provided by ISMT that is available for instructors to evaluate the participant when using the system. The information provided included round count, score, and pictures of each target with markers to represent where the shots intersected the target. In addition to receiving immediate feedback from ISMT, the simulation group also received feedback from the instructor. The M9 magazine contained only six rounds for the unlimited scenario. More rounds could have been programmed into the system; however, having only six rounds required the participants to load and unload magazines more frequently, providing more reload practice. For both groups, the instructor ensured that the participant was lined up on the center line of the respective target at which the participant was aiming. No data was collected from this scenario.

3. Navy Handgun Qualification Course Firing Sequence

The last scenario used was the NHQC firing sequence. All data collection occurred using this scenario. The NHQC firing sequence scenario consisted of three separate Transtar II silhouette targets, displayed one at a time and synced with the recorded instructions. Each target would appear once the recorded instructions were complete and prior to the first shot (see Figure 1).

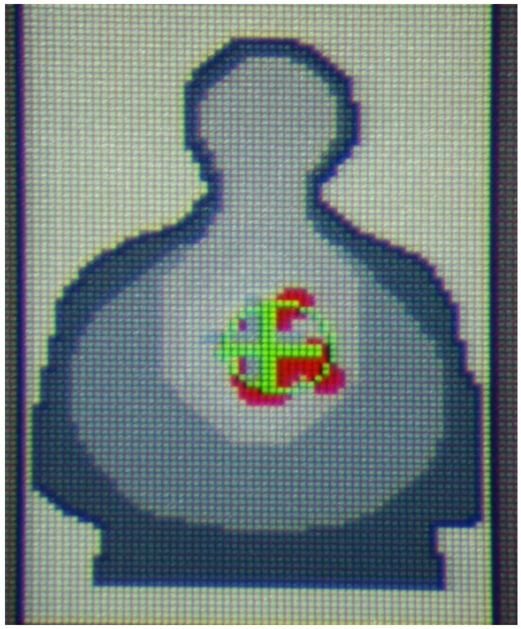

Figure 1. Transtar II Silhouette Target

After the last cease fire instruction played, the target would disappear. The participant was given two magazines with six rounds in each magazine for the 3- and 7-yard line firing sequences. For the 15-yard line firing sequence, the participant was given two magazines with 12 rounds in each magazine. The recorded instructions for the NHQC firing sequence were recorded verbatim from OPNAVINST 3591.1F (Chief of Naval Operations, 2009). For more information on voice recorded training instructions, see Getty (2008). Refer to Table 3 for a detailed description of NHQC firing sequence, Figure 2 for the participant's view of the simulated range, and Figure 3 for the instructor's control panel display screen.

Table 3. Navy Handgun Qualification Course Firing Sequence

Yard Line	Rounds	Sequence	Remarks
3	12	Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds, reload 6 rounds and fire 2 rounds in 10 seconds	4 rounds strong hand supported position
		Draw and fire 4 rounds in 8 seconds	2 rounds strong hand supported position, 2 rounds weak hand supported position
7	12	Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds, reload 6 rounds and fire 2 rounds in 10 seconds	4 rounds strong hand supported position
		Draw and fire 4 rounds in 8 seconds	2 rounds strong hand supported position, 2 rounds weak hand supported position
15	24	Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 4 rounds in 8 seconds	4 rounds strong hand supported position
		Draw and fire 4 rounds, reload 12 rounds and fire 4 rounds in 10 seconds	8 rounds strong hand supported position
		Draw and fire 8 rounds in 20 seconds	8 kneeling position

Figure 2. Participant's View

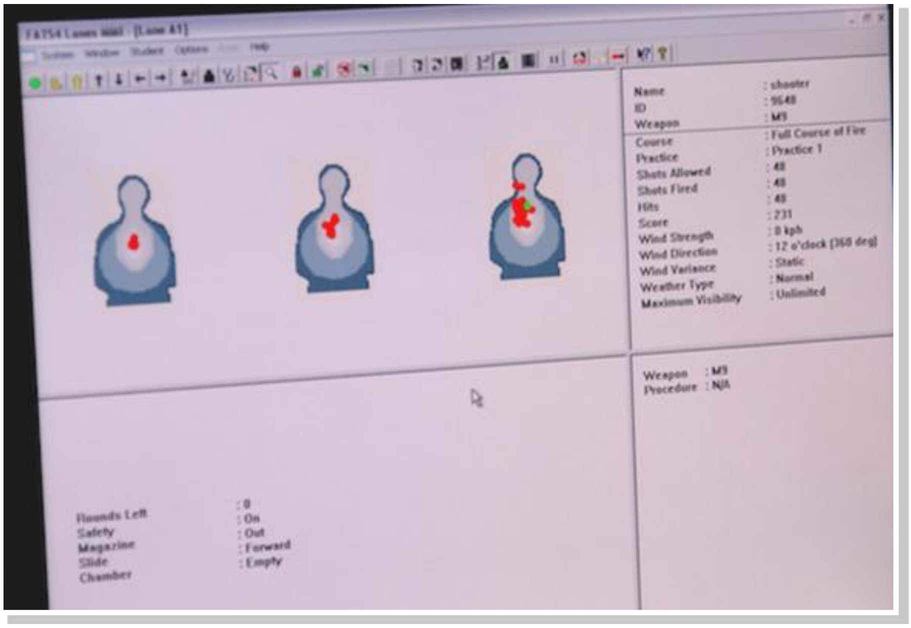

Figure 3. Instructor Control Panel

F. PROCEDURES

All participants were active duty U.S. military members and either NPS students or faculty. Recruitment was conducted via e-mail. Prior to a participant's first session, a demographic survey was sent in a separate e-mail with instructions to bring the completed survey to the participant's first session. The demographics survey contained questions about the participants' general characteristics, marksmanship skill level, and marksmanship experience.

Participants were randomly assigned into four groups. Training time blocks of 50 minutes each were pre-designated, based on the authors' schedules, as available training time sessions. Time blocks were sent to each participant and the participant was instructed to sign up for the first session, with the second session as an automatic assignment that was the same day and time as the first session, but exactly one week later. The authors randomly designated time blocks as either control group or simulation group prior to participants signing up for training sessions. Participants were unaware of which group they were assigned to until they arrived for their second training session.

A baseline of their current level of marksmanship performance and score was recorded via the ISMT before exposure to either training condition. The control groups

received SNMT using the ISMT unlimited practice scenario screen to provide visual Transtar II silhouette target s for the training session, but received no system feedback during the training session, and the simulation groups received simulation training using the ISMT unlimited practice scenario with full system feedback during the training session. One control group and simulation group received no additional training for two weeks, while the other control group and simulation group received no additional training for four weeks. After their respective time lapse, all groups conducted a final live fire NHQC firing sequence to determine retention of marksmanship knowledge.

Groups were staggered so only four participants completed the live fire events at a time. During all NHQC firing sequences, data regarding participants' MPI and performance score were collected. The dependent variables were MPI of group shots and scores from the NHQC firing sequence. The participants were not video or audio recorded at any time. Appropriate statistical analyses on the performance scores and MPI were used to test the hypotheses.

During the course of this research, several controls were in place to ensure standardization. In the scheduling phase of this research, when participants signed up for the first training session they needed to ensure they were available to complete their second training session exactly one week later. Each training session was limited to 50 minutes to ensure every participant received an equal amount of training time. All participants used the isosceles standing position for the first 36 rounds fired and the isosceles kneeling position for the last 12 rounds fired to mitigate any confounds associated with various firing positions and maximize consistency (see Figures 4 and 5).

Figure 4. Isosceles Standing Position (From Headquarters, United States Marine Corps, 2003)

Figure 5. Isosceles High Kneeling Position (From Headquarters, United States Marine Corps, 2003)

The NHQC firing sequence was used for all data collection shooting events. Each participant shot from the same location marked by blue masking tape on the floor of the ISMT trailer to indicate the center line to help participants center their bodies on the target. Every participant used the same style holster for both simulation and live fire events, which consisted of a standard issue police officer holster with weapon locking mechanism. Each participant was instructed to place the weapon in the holster in such a way that the weapon rested just above the locking mechanism threshold, thus ensuring the weapon never locked while in the holster. The holster belt was fully adjustable, thereby allowing each participant to adjust as needed to ensure a proper fit. All instructions were recorded verbatim from OPNAVINST 3591.1F (Chief of Naval Operations, 2009) to ensure standardization and consistency.

Before participants arrived for a session, the authors ensured the ISMT was ready. First, a ready line and a firing line were established in accordance with OPNAVINST 3591.1F (Chief of Naval Operations, 2009) and marked in ISMT by placing masking tape

on the deck at the appropriate distances from the projector screen. General safety rules were posted next to the firing line and participants were instructed to read them prior to commencing training. The authors utilized a personal laptop with audio files containing recorded instructions. The laptop was connected to speakers mounted in various locations inside the ISMT lab. The authors ensured the ISMT system was calibrated prior to each participant's arrival. Following system calibration, the M9 was registered and calibrated to the ISMT. The registration process consisted of the instructor firing one round at the screen when prompted by the ISMT. The laser-reading camera would read the individual pulse-coded laser for that particular weapon and register it in the ISMT system. The weapon calibration process is mentioned above in the zeroing scenario. During the first training session, each participant provided a unique, four-digit identifier that was used to correlate performance data to that participant through all training and evaluation sessions.

Prior to beginning the baseline training, every participant received a safety brief in addition to an overview of the procedures used in this part of the training. The safety brief was conducted in accordance with OPNAVINST 3591.1F (Chief of Naval Operations, 2009) to ensure all safety requirements were met. Baseline training ensured that every participant began with a basic level of knowledge on how to properly handle and fire the M9, which included the proper use of the M9 and specific weapon commands for the experiment (Getty, 2008). Table 4 provides a detailed description of the baseline training topics.

Table 4. Baseline Training Program (From Getty, 2008)

Baseline Training
General Range Safety Rules
General Safety Rules
Weapon Conditions
Weapon Commands
Pistol Safety Rules
Ready Line
Firing Line
Range Operations
Training Time Out
Loading the Pistol
Making the Pistol Ready
Fire
Cease Fire
Unload, Showing the Pistol Clear
Dry Reload
Isosceles only
Isosceles Standing Position
Isosceles High Kneeling Position

Immediately following baseline training, a baseline simulation shooting event was administered to each participant using the NHQC firing sequence. The purpose of this shooting event was to establish baseline performance of for each participant to compare to their post-training performance.

The next training session consisted of either control group training or simulation group training. No participant was aware of which group they were in until they showed up for the second training session. The control group training for this thesis followed the control group training that Getty (2008) used:

> The control group training program was created by using enclosure two of the OPNAVINST 3591.1F (Chief of Naval Operations, 2009), chapter two of the NTRP3–07.2.2 (U.S. Fleet Forces Command, 2003) and chapter three of the MCRP 3–01B (Headquarters, United States Marine Corps, 2003). The participants were allowed to handle the M9 Berretta and follow along with the recorded lessons. It was important that the participants were afforded the opportunity to practice without any time constraints. During the lecture, the participants focused on slow, smooth and methodical motions when drawing and dry firing the pistol. The

participants in the control group received 18 minutes of recorded lecture. (p. 10)

The unlimited practice scenario was used for control group training, which displayed three Transtar II silhouette target s simultaneously for the 3-, 7-, and 15-yard lines. During this training, the M9 was disconnected from the ISMT. The only immediate feedback available to control group participants was from the instructor. Table 5 provides a detailed description of the control group training topics.

Table 5. Control Group, Marksmanship Fundamental Training Program (From Getty, 2008)

Control Group Training
Dry Fire Safety Training
Drawing Process
Grab
Draw
Smack
Look Squeez
Holstering
Introduction to Fundamentals
Aiming
Sight Alignment
Establishing Sight Alignment
Grip with respect to (WRT) Aiming
Controlled Muscular Tension
Sight Picture
Relationship Betweent the Eye and the Sights
Trigger Control
Sight Alignment and Trigger Control
Grip WRT Trigger Control
Trigger Finger Placement
Uninterrupted Trigger Control
Interrupted Trigger Control
Breath Control
Begin Dry Fire Training
Single Action
Five to Ten Times Repitition
Start Adding Time Limits
Draw Sweep Safety Dry Fire

Immediately following control group training, the M9 was reconnected to the ISMT and the post-training shooting event was administered using the NHQC firing sequence. The purpose of this shooting event was to compare post-training performance to the participants' baseline performance.

The simulation group training was similar to the control group except that instead of dry fire training, the M9 was connected to the ISMT system to provide system and audio feedback of shots fired and connected to the CO_2 cylinder to provide simulated recoil for the weapon. The instructor's control panel was turned toward the participant,

providing the same system-generated feedback that is provided for the instructor to evaluate the participant. The information provided included round count, score, and pictures of each target with markers to represent where the shots intersected the target. The training duration was 16 minutes; two minutes shorter than control group training. The shorter training time is due to not having to provide dry fire instructions, but was compensated by showing simulation group participants trace profiles from their baseline qualification shooting event. The simulation group participants also utilized the unlimited practice scenario. Table 6 provides a detailed description of the simulation group training.

Table 6. Simulation Group Training, Marksmanship Fundamental Training Program (From Getty, 2008)

Simulation Group Training
Simulation Safety Training
Drawing Process
Grab
Draw
Smack
Look Squeez
Holstering
Introduction to Fundamentals
Aiming
Sight Alignment
Establishing Sight Alignment
Grip with respect to (WRT) Aiming
Controlled Muscular Tension
Sight Picture
Relationship Betweent the Eye and the Sights
Trigger Control
Sight Alignment and Trigger Control
Grip WRT Trigger Control
Trigger Finger Placement
Uninterrupted Trigger Control
Interrupted Trigger Control
Breath Control
Begin Simulation Training

Immediately following simulation group training, a post-training shooting event was administered using the NHQC firing sequence. The purpose of this shooting event was to compare post-training performance to the participants' baseline performance.

Figure 6 is a visual representation of the research.

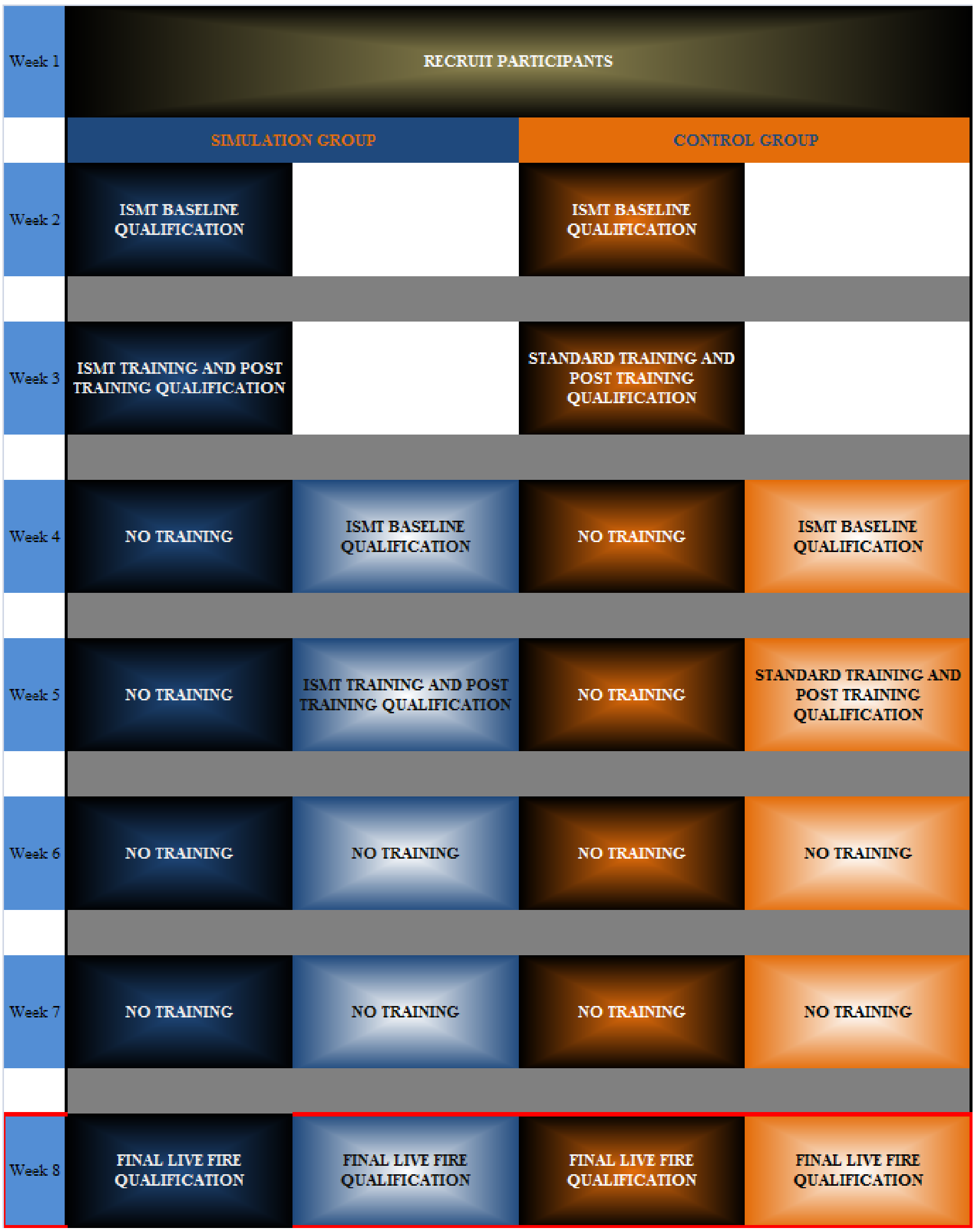

Figure 6. Research Design

A detailed description of the research design is as follows:

Week 1:

All Participants: Thirty-four participants were recruited. A demographic survey was administered prior to the beginning of the experiment to gather information about previous marksmanship experience. Questions included general characteristics, marksmanship skill level, and weapon experience.

Week 2:

First Control Group: Baseline ISMT event consisting of the NHQC firing sequence was administered to establish their current level of marksmanship.

First Simulation Group: Baseline ISMT event consisting of the NHQC firing sequence was administered to establish their current level of marksmanship.

Week 3:

First Control Group: Received SNMT, which involved demonstrating proper techniques for marksmanship including proper stance, proper breathing control, and conducting dry fire with a simulated M9. These participants had the opportunity to fire practice shots at simulated Transtar II silhouette targets, but no system feedback was provided from ISMT. Once training was complete, a post-training ISMT event consisting of the NHQC firing sequence was administered to establish any differences between post-training and baseline.

First Simulation Group: Received simulation-based training in the ISMT, which involved demonstrating proper techniques for marksmanship including proper stance, proper breathing control, and conducting dry fire with a simulated M9. These participants also had the opportunity to fire practice shots at simulated Transtar II silhouette targets, and analyze their trace profiles and grouping of shots. The analysis component was the difference in training between the control and simulation groups. Once training was complete, a post-training ISMT event consisting of the NHQC firing sequence was administered to establish any differences between post-training and baseline.

Week 4:

First Control Group: Received no additional training.

First Simulation Group: Received no additional training.

Second Control Group: Baseline ISMT event consisting of the NHQC firing sequence was administered to establish their current level of marksmanship.

Second Simulation Group: Baseline ISMT event consisting of the NHQC firing sequence was administered to establish their current level of marksmanship.

Weeks 5:

First Control Group: Received no additional training.

First Simulation Group: Received no additional training.

Second Control Group: Received SNMT, which involved demonstrating proper techniques for marksmanship including proper stance, proper breathing control, and conducting dry fire with a simulated M9. These participants had the opportunity to fire practice shots at simulated Transtar II silhouette targets, but no system feedback was provided from ISMT. Once training was complete, a post-training ISMT event consisting of the NHQC firing sequence was administered to establish any differences between post-training and baseline.

Second Simulation Group: Received simulation-based training in the ISMT, which involved demonstrating proper techniques for marksmanship including proper stance, proper breathing control, and conducting dry fire with a simulated M9. These participants also had the opportunity to fire practice shots at simulated Transtar II silhouette targets, and analyze their trace profiles and grouping of shots. The analysis component was the difference in training between the control and simulation groups. Once training was complete, a post-training ISMT event consisting of the NHQC firing sequence was administered to establish any differences between post-training and baseline.

Weeks 6:

All Participants: Received no additional training.

Week 7:

All Participants: Received no additional training.

Week 8:

All Participants: Conducted live fire events at Laguna Seca Range on the NHQC firing sequence. Prior to beginning the live fire events, the RSO provided a safety brief to participants. This shooting event determined how much carryover each participant had of marksmanship skills from simulation to the live fire event with a two- or four-week gap. This was the final event for all groups.

III. RESULTS

A. DATA PREPARATION AND STATISTICAL METHODS

Demographics survey data was transcribed from paper surveys and recorded in an Excel spreadsheet. It was analyzed using two-proportion Z-tests, χ^2, and two-sample *t*-tests with the data analysis tool package in Excel 2007.

All experimental data sets from ISMT were transcribed from computer-generated data screens into an Excel spreadsheet, a picture of each data screen in ISMT was taken for back up, and a video of each trace profile was recorded for each ISMT event. The live fire event paper targets were graded without knowledge of which group the shooter was assigned. All live fire data sets were recorded in an Excel spreadsheet. Experimental data sets were analyzed using two-sample *t*-tests, paired *t*-tests, and Wilcoxon Rank Sum Tests. Statistical calculations for experimental data sets were accomplished using the data analysis tool package in Excel 2007 or JMP 9.

The two main variables for hypothesis testing were MPI and score. MPI is defined in Joint Publication 1–02 as "[t]he point whose coordinates are the arithmetic means of the coordinates of the separate points of impact/burst of a finite number of projectiles fired or released at the same aiming point under a given set of conditions" (Joint Chiefs of Staff, 2010, p. 207). MPI is measured in centimeters, with lower values indicating more accurate performance. Scores were assessed based on OPNAVINST 3591.1F (Chief of Naval Operations, 2009). As stated in Chapter II, each shooter participated in three shooting events: an initial baseline shooting event in ISMT, a post-training shooting event in ISMT, and a final live fire shooting event at Laguna Seca Peace Corps Range. Each shooting event consisted of three distances: 3-, 7-, and 15-yards. Scores and MPI for each distance were recorded for all shooting events. ISMT provided the MPI for each target simulation as well as the average MPI across the three distances. For each paper target from the live fire event, the MPI for each distance from the target was calculated by measuring the distance between the shot and the center of the target. The average MPI for the live fire event was then calculated in Excel. To reduce Type I error, the averaged MPI across the three distances from the target for each

shooting event was used for hypothesis testing. Scoring for each shooting event was graded in accordance with the NHQC instruction, based on each shooter's performance, with higher scores indicating better performance. There was a miscalculation in the user-defined ISMT scenario for the average group shot, so that variable was not analyzed in this research.

For the averaged MPIs and score, difference scores were calculated on the following data sets: baseline to post-training performance, baseline to live fire performance, and post-training to live fire performance. The difference scores were used to assess changes in performance over time (i.e., across the three shooting events) to determine whether any significant improvement or degradation occurred within each group. These difference scores were analyzed using two-sample *t*-tests to determine whether or not the simulation group showed greater levels of improvement than the control group. These difference scores also were used to test the hypothesis regarding change in performance between participants, with a two-week gap and those with a four-week gap, from post-training to live fire. The control and simulation group sizes for this research were too small to effectively test hypothesis two. Therefore, the group with a two-week gap between post-training and live fire had seven participants in the simulation group and eight in the control group; and the group with a four-week gap between post-training and live fire had five participants in the simulation group and seven in the control group.

A one-tailed alpha of 0.05 was used for all hypothesis testing.

A non-parametric Wilcoxon Rank Sum Test was used on all difference scores, difference MPI measurements, and two-week to four-week gap comparisons due to violation of the normality assumption. All Wilcoxon Rank Sum Tests were performed in JMP 9. The results from all non-parametric tests had the same pattern as the two-sample *t*-tests. Therefore, only two-sample *t*-test results are described for ease of interpretation. An *F*-test was calculated on each data set to check the equal variance assumption prior to conducting a two-sample *t*-test for each comparison. Based on the results of the *F*-test, the appropriate two-sample *t*-test was selected. All *F*-tests and *t*-tests were performed in Excel.

B. PRELIMINARY ANALYSES

1. Preliminary Analysis for Hypothesis One

Before conducting testing for hypothesis one, scores and MPI measurements were evaluated on the following data sets to determine if there were differences in performance levels during each evaluated shooting event between the control group and the simulation group: (1) at baseline, (2) at post-training, and (3) at live fire. First, the baseline performance between groups at baseline was compared to determine if the groups started at the same level of marksmanship performance. Then, a within-group analysis was conducted to examine whether each group showed significant improvement from baseline.

a. Scores

The P-values indicated no significant baseline difference in scores between the control and simulation group in any of the shooting events. Comparisons of the baseline shooting events suggest that the simulation group (210.33 ± 21.94 points) was performing slightly better than the control group (201.44 ± 21.25 points) for score; a point that will be further discussed in Chapter IV. There also was a trend for the simulation group to outperform the control group in post-training ($t(29) = -1.38$, $p = 0.089$). Both groups showed significant improvement from baseline. The P-values suggest that the control group showed significant improvement in score from baseline to post-training (mean difference = 26.88 ± 16.16 points), ($t(15) = 6.65$, $p < 0.0001$), and from baseline to live fire (mean difference = 15.81 ± 15.48 points), ($t(15) = 4.09$, $p = 0.0005$). The simulation group also showed significant improvement in score from baseline to post-training (mean difference = 22.40 ± 19.98 points), ($t(14) = 4.34$, $p = 0.0003$), and from baseline to live fire (mean difference = 7.83 ± 13.69 points), ($t(11) = 1.98$, $p = 0.0365$).

b. MPI

The P-values indicated no significant baseline difference in MPI between the control and simulation group at baseline. However, the simulation group

outperformed the control group in MPI at post-training ($t(29) = 2.52$, $p = 0.009$) and live fire (t(26) = –0.77, p = 0.020). These results are consistent with the within-group analyses. The control group showed significant degradation in MPI from post-training to live fire (mean degradation = 2.79 ± 3.26 cm), ($t(15) = 2.38$, $p = 0.0154$), whereas the simulation group was less likely to show degraded MPI performance from post-training to live fire (mean degradation = 2.51 ± 3.05 cm), ($t(11) = 1.60$, $p = 0.0685$).

Means and standard deviations for scores and MPI at each shooting event by group are shown in Table 7.

Table 7. Comparison of Control and Simulation Groups at Each Shooting Event

		Baseline			**Post-Training**			**Live Fire**	
		Control (n=16)	*Simulation (n=15)*		*Control (n=16)*	*Simulation (n=15)*		*Control (n=16)*	*Simulation (n=12)*
Score	Mean	201.44	210.33	Mean	228.31	232.73	Mean	217.25	222.67
	sd	21.25	21.94	*sd*	8.90	8.90	*sd*	20.55	14.90
MPI	Mean	5.28	5.25	Mean	4.13	2.61	Mean	6.85	4.92
	sd	2.37	2.05	*sd*	1.95	1.31	*sd*	2.86	2.18

Bar charts with standard error bars are provided for scores (Figure 7) and MPI (Figure 8) for a visual representation of each shooting event.

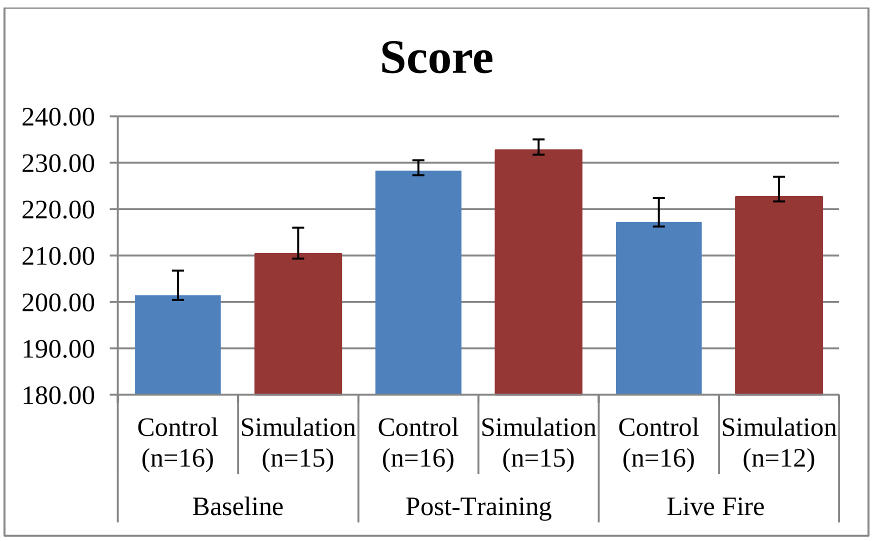

Figure 7. Bar Chart of Score Comparison of Control and Simulation

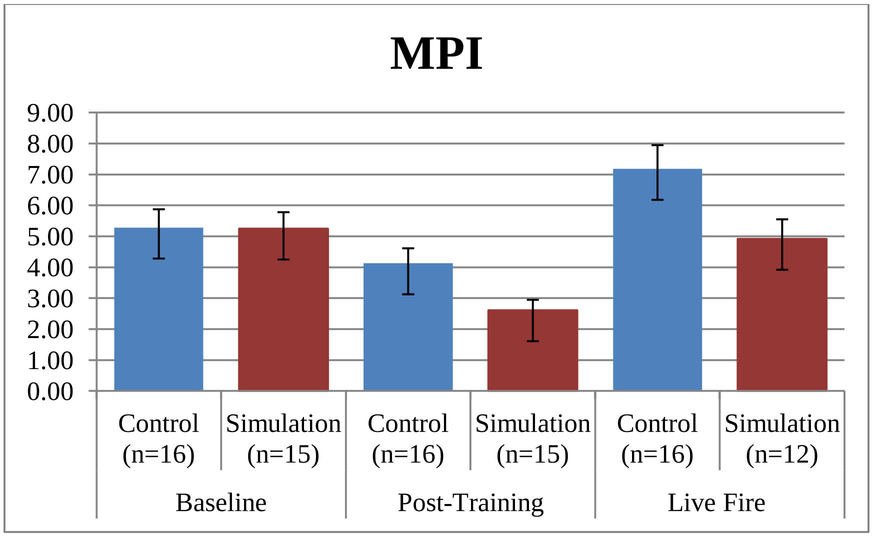

Figure 8. Bar Chart of MPI Comparison of Control and Simulation Groups

2. Preliminary Analysis for Hypothesis Two

Before conducting testing for hypothesis two, scores and MPI measurements were evaluated on the following data sets to determine if there was a difference in performance levels during each evaluated shooting event between participants with a two-week gap from post-training to live fire (two-week gap group) and participants with a four-week gap from post-training to live fire (four-week gap group): (1) at baseline, (2) at post-training, and (3) at live fire.

a. Scores

While the P-values indicate no significant baseline difference in scores between the two-week gap group and the four-week gap group in any of the shooting events, the post-training scores trend toward significance in which the two-week gap group outperformed the four-week gap group ($t(23) = 1.56$, $p = 0.067$). The paired t-test indicated that both the two- and four-week gap groups showed significant improvement in score from baseline to live fire (two-week gap: 9.93 ± 12.19 points), ($t(14) = 3.16$, $p = 0.0035$; four-week gap: $15.23 + 17.84$ points), ($t(12) = 3.08$, $p = 0.0048$).

b. MPI

There was a trend for the two-week gap group to outperform the four-week gap group at baseline ($t(29) = 1.38$, $p = 0.089$) and post-training ($t(29) = -1.65$, $p = 0.055$) on MPI. However, the two-week gap group actually showed more degradation in MPI from post-training to live fire (mean degradation = 3.41 ± 3.10 cm), ($t(14) = 2.85$, $p = 0.0064$) than the four-week group (mean degradation = 2.15 ± 3.21 cm), ($t(12) = 1.28$, $p = 0.1117$).

Means and standard deviations for scores and MPI at each shooting event by time gap are shown in Table 8.

Table 8. Comparison of Two- and Four-Week Time Gaps Between Post-Training and Live Fire at Each Shooting Event

	Baseline			**Post-Training**			**Live Fire**		
		2 Weeks (n=16)	*4 Weeks (n=15)*		*2 Weeks (n=16)*	*4 Weeks (n=15)*		*2 Weeks (n=15)*	*4 Weeks (n=13)*
Score	Mean	207.94	203.40	Mean	232.88	227.87	Mean	219.27	219.92
	sd	21.18	22.73	*sd*	6.56	10.72	*sd*	17.60	19.66
MPI	Mean	5.78	4.71	Mean	2.89	3.93	Mean	6.32	6.09
	sd	1.98	2.32	*sd*	1.49	2.02	*sd*	2.89	3.04

Bar charts with standard error bars are provided for scores (Figure 9) and MPI (Figure 10) for a visual representation of each shooting event.

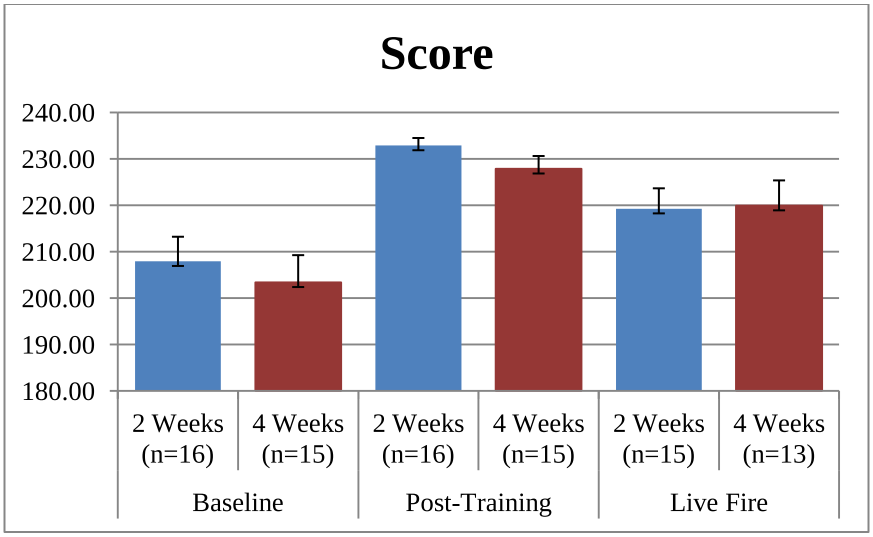

Figure 9. Bar Chart of Score Two- and Four-Week Time Gaps Between Post-Training and Live Fire

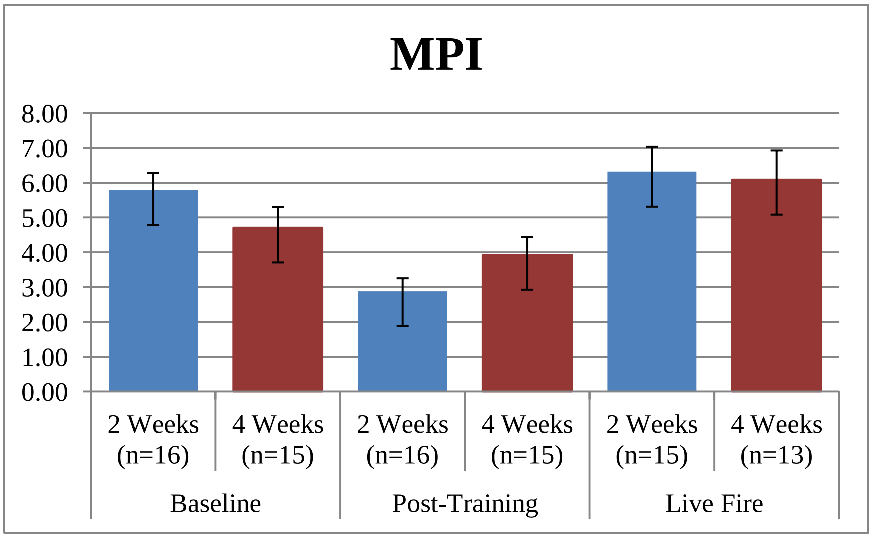

Figure 10. Bar Chart of MPI Two- and Four-Week Time Gaps Between Post-Training and Live Fire

C. HYPOTHESIS TESTING AND ANALYSIS

1. Hypothesis One

$H0_1$: There will be no group differences in the participants' MPI of shots and scores in the NHQC firing sequence from baseline to live fire.

HA_1: Participants who receive simulation-based training in ISMT will have a greater improvement in MPI of shots and scores in the NHQC firing sequence when comparing the difference between baseline and live fire than participants who receive SNMT.

Change in scores and MPI measurements were evaluated on the following data sets to assess changes in performance between the control group and the simulation group: (1) between baseline and post-training events, (2) between post-training and live fire events, and (3) between baseline and live fire events.

a. Scores

No significant group differences were found in assessing changes in score performance in any shooting event comparison. However, the control group displayed a trend for greater improvement than the simulation group from baseline to live fire ($t(26) = 1.42$, $p = 0.084$).

b. MPI

The P-values indicate significant differences in change in MPI performance from baseline to live fire, where the simulation group showed essentially no degradation from baseline to live fire; however, the control group showed degradation in its difference MPI measurements ($t(26) = 1.83$, $p = 0.039$). The simulation group also demonstrated a trend for greater improvement than the control group from baseline to post-training ($t(29) = 1.58$, $p = 0.063$).

Means and standard deviations for difference scores and difference MPI for each pair of shooting events by group are shown in Table 9.

Table 9. Comparison of Control and Simulation Groups for Differences in Score and MPI

		Difference (Baseline to Post-Training)			Difference (Post-Training to Live Fire)			Difference (Baseline to Live Fire)	
		Control (n=16)	*Simulation (n=15)*		*Control (n=16)*	*Simulation (n=12)*		*Control (n=16)*	*Simulation (n=12)*
Score	Mean	26.88	22.40	Mean	–11.06	–11.50	Mean	15.81	7.83
	sd	16.16	19.98	*sd*	14.62	12.94	*Sd*	15.48	13.69
MPI	Mean	–1.16	–2.64	Mean	2.79	2.51	Mean	1.75	–0.01
	sd	2.47	2.77	*sd*	3.26	3.05	*Sd*	2.99	2.39

2. Results of Hypothesis One Testing and Analysis

$H0_1$ is partially rejected. The simulation group showed significantly less degradation in MPI performance than the control group. However, there was a trend towards significance for the control group to show greater improvement in scores than the simulation group.

3. Hypothesis Two

$H0_2$: Participants in each group will be equally likely to maintain their MPI of shots and scores on the NHQC two weeks and four weeks after the training day.

HA_2: Participants who receive simulation-based training in ISMT will be more likely than those in the control group to maintain their MPI of shots and scores in the NHQC two weeks and four weeks after the training day.

Changes in scores and MPI measurements were evaluated on the following data sets to assess maintenance of performance between the two-week gap group and the four-week gap group: (1) between post-training and live fire events and (2) between baseline and live fire events.

a. Scores

The P-values show no significant differences between the two-week gap group and the four-week gap group for scores in any of the cases tested. Both groups showed a pattern of performance degradation from post-training to live fire, but an overall improvement from baseline to live fire.

b. MPI

There were no significant differences found between the two-week gap group and the four-week gap group from the baseline to live fire or from the post-training to live fire comparisons. Both groups showed degradation in MPI performance over the retention interval.

Means and standard deviations difference scores and difference MPI for each pair of shooting events by time gap are shown in Table 10.

Table 10. Comparison of Two- and Four-Week Time Gaps Between Post-Training and Live Fire for Differences in Score and MPI

		Difference (Baseline to Post-Training)			**Difference (Post-Training to Live Fire)**			**Difference (Baseline to Live Fire)**	
		2 Weeks (n=16)	*4 Weeks (n=15)*		*2 Weeks (n=15)*	*4 Weeks (n=13)*		*2 Weeks (n=15)*	*4 Weeks (n=13)*
Score	Mean	24.94	24.47	Mean	–13.40	–8.77	Mean	9.93	15.23
	sd	21.08	14.62	*sd*	15.38	11.50	*sd*	12.19	17.84
MPI	Mean	–2.90	–0.78	Mean	3.41	2.15	Mean	0.69	1.53
	sd	2.76	2.18	*sd*	3.10	3.21	*sd*	322	2.38

4. Results of Hypothesis One Testing and Analysis

$H0_2$ is retained. The P-values show no significant differences between the two- and four-week gap groups for scores or MPI in any of the cases tested.

D. EXPLORATORY ANALYSES

As noted above, each shooter participated in an initial baseline simulation shooting event, a post-training simulation shooting event, and a final live fire shooting event. For all shooting events, the shot group diameter was also recorded. Targets were changed out at each firing distance (3, 7, and 15 yards) in the live fire shooting event to facilitate comparisons with the data collection from ISMT. For analytical purposes, the shot group diameter for the paper targets in the live fire event was calculated by measuring the distance between the outside diameters of the farthest two bullet intersections on the target and subtracting the size of the bullet to compensate for center of bullet impact with the target. For the ISMT targets, the measurements were calculated

by the computer software where the system recorded the laser intersection with the target and displayed the distance on the results screen. Therefore, exploratory analyses were conducted on these variables at the three different distances to gain greater insight into the main results. All exploratory analyses results should be interpreted with caution due to the small sample size and increased probability of Type I error.

1. Control Group to Simulation Group Comparisons at Each Distance From Target

a. MPI

The P-values indicate that the simulation group performed better than the control group at the 7- and 15-yard distances during post-training and at the 3-yard distance for live fire. There was a trend for the simulation group to show less degradation from baseline to live fire ($t(18) = 1.46$ $p = 0.08$) and post-training to live fire ($t(18) = 1.62$, $p = 0.06$) for the 3-yard distance than the control group. The simulation group's MPI score degraded from post-training to live fire, on average, by (0.29 ± 1.38 cm), whereas the control group degraded by (2.30 ± 4.68 cm). Similarly, from baseline to live fire, the simulation group degraded, on average, by only (0.09 ± 1.39 cm), whereas the control group degraded by (1.99 ± 4.97 cm).

Table 11 provides means and standard deviations for MPI and associated one tail P-value at each distance from target for baseline, post-training, and live fire by group.

Table 11. Comparison of Control and Simulation Groups for MPI at 3, 7, and 15 Yards

	Baseline			Post-Training			Live Fire		
		Control (n=16)	*Simulation (n=15)*		*Control (n=16)*	*Simulation (n=15)*		*Control (n=16)*	*Simulation (n=12)*
MPI at 3 yards	Mean	2.24	2.35	Mean	1.93	1.87	Mean	4.23	2.01
	sd	1.08	1.45	*sd*	0.74	0.92	*Sd*	4.48	0.89
	P(T<=t) one-tail		0.4065	P(T<=t) one-tail		0.4153	P(T<=t) one-tail		**0.0349**
MPI at 7 yards	Mean	5.96	5.72	Mean	4.47	3.02	Mean	5.73	4.45
	sd	2.83	2.43	*sd*	2.07	1.45	*Sd*	4.28	2.49
	P(T<=t) one-tail		0.4028	P(T<=t) one-tail		**0.0163**	P(T<=t) one-tail		0.1642
MPI at 15 yards	Mean	8.58	8.50	Mean	6.71	4.59	Mean	11.01	8.90
	sd	4.12	3.29	*sd*	3.22	2.17	*Sd*	5.28	3.50
	P(T<=t) one-tail		0.4761	P(T<=t) one-tail		**0.0210**	P(T<=t) one-tail		0.1203

b. Shot Group Diameter

The P-values indicate no significant differences at any distance from the target between the simulation and control groups for shot group diameter.

Table 12 provides means and standard deviations for shot group diameter and associated one tail P-value at each distance from the target for baseline, post-training, and live fire by group.

Table 12. Comparison of Control and Simulation Groups for Shot Group Diameters at 3, 7, and 15 Yards

	Baseline			Post-Training			Live Fire		
		Control (n=16)	*Simulation (n=15)*		*Control (n=16)*	*Simulation (n=15)*		*Control (n=16)*	*Simulation (n=12)*
Shot Group at 3 yards	Mean	9.76	8.47	Mean	7.03	6.31	Mean	15.85	13.64
	sd	4.70	4.05	*sd*	3.29	2.38	*Sd*	7.13	5.93
	P(T<=t) one-tail		0.2119	P(T<=t) one-tail		0.2472	P(T<=t) one-tail		0.1961
Shot Group at 7 yards	Mean	20.31	15.96	Mean	15.24	12.61	Mean	25.05	20.66
	sd	14.12	7.90	*sd*	6.67	6.52	*Sd*	10.38	7.24
	P(T<=t) one-tail		0.1505	P(T<=t) one-tail		0.1388	P(T<=t) one-tail		0.1109
Shot Group at 15 yards	Mean	37.34	32.31	Mean	27.56	26.98	Mean	41.13	40.45
	sd	26.01	14.78	*sd*	17.14	7.41	*Sd*	12.19	12.54
	P(T<=t) one-tail		0.2555	P(T<=t) one-tail		0.4517	P(T<=t) one-tail		0.4439

2. Two- and Four-Week Gaps Between Post-Training and Live Fire Comparisons at Each Distance From Target

a. MPI

The P-values indicate significant differences in MPI for the 3-yard distance from the target in the baseline, with the four-week gap group having a smaller MPI than the two-week gap group. A significant difference was found in the change in MPI between post-training and live fire at the 3-yard distance. The two-week gap group showed improvement from baseline to live fire (–0.11 ± 1.40 cm), whereas the four-week gap group showed degradation from baseline to live fire (2.66 ± 5.29 cm), ($t(13) = –1.84$, $p = 0.045$). There was also a trend towards significance where the two-week gap group showed less degradation (0.50 ± 1.59 cm) than the four-week gap group from post-training to live fire (2.52 ± 5.11 cm), ($t(14) = –1.36$, $p = 0.097$).

Table 13 provides means and standard deviations for MPI and associated one tail P-value at each distance from the target for baseline, post-training, and live fire by time gap.

Table 13. Comparison of Two- and Four-Week Gaps Between Training and Live Fire MPI at 3, 7, and 15 Yards

	Baseline			Post-Training			Live Fire		
		2 Weeks (n=16)	*4 Weeks (n=15)*		*2 Weeks (n=16)*	*4 Weeks (n=15)*		*2 Weeks (n=15)*	*4 Weeks (n=13)*
MPI at 3 yards	Mean	2.69	1.87	Mean	1.92	1.88	Mean	2.43	4.26
	sd	1.17	1.24	*sd*	0.75	0.91	*Sd*	1.28	4.99
	P(T<=t) one-tail		**0.0336**	P(T<=t) one-tail		0.4489	P(T<=t) one-tail		0.1110
MPI at 7 yards	Mean	6.18	5.47	Mean	3.33	4.23	Mean	5.25	5.10
	sd	2.77	2.45	*sd*	1.36	2.33	*Sd*	3.82	3.53
	P(T<=t) one-tail		0.2333	P(T<=t) one-tail		0.1024	P(T<=t) one-tail		0.4561
MPI at 15 yards	Mean	9.23	7.81	Mean	5.13	6.27	Mean	10.70	9.42
	sd	3.32	4.02	*sd*	2.59	3.22	*Sd*	4.74	4.64
	P(T<=t) one-tail		0.1446	P(T<=t) one-tail		0.1421	P(T<=t) one-tail		0.2396

b. Shot Group Diameter

The P-values indicate no significant differences at any distance from the target between the two-week gap group and the four-week gap group for shot group

diameter. There were trends towards significance between the post-training and live fire at the 15-yard distance from the target, where the four-week gap group had less degradation in shot group diameter (10.12 ± 17.12 cm) than the two-week gap group (19.59 ± 12.11 cm), ($t(24) = 1.65$, $p = 0.056$); the baseline and live fire at the 3-yard distance from the target, where the four-week gap group had less degradation in shot group diameter (4.35 ± 2.79 cm) than the two-week gap group (6.96 ± 6.90 cm), ($t(19) = 1.34$, $p = 0.097$); and the baseline and live fire at the 15-yard distance from the target, where the four-week gap group had less degradation in shot group diameter (0.80 ± 26.05 cm) than the two-week gap group (11.96 ± 16.28 cm), ($t(24) = 1.33$, $p = 0.098$).

Table 14 provides means and standard deviations for shot group diameter and associated one tail P-value at each distance from the target for baseline, post-training, and live fire by time gap.

Table 14. Comparison of Two- and Four-Week Gaps Between Training and Live Fire of Shot Group Diameters at 3, 7, and 15 Yards

	Baseline			**Post-Training**			**Live Fire**		
		2 Weeks (n=16)	*4 Weeks (n=15)*		*2 Weeks (n=16)*	*4 Weeks (n=15)*		*2 Weeks (n=15)*	*4 Weeks (n=13)*
Shot Group at 3 yards	Mean	9.15	9.12	Mean	7.19	6.13	Mean	16.32	13.26
	sd	3.33	5.40	*sd*	3.53	1.89	*Sd*	7.51	5.23
	P(T<=t) one-tail		0.4927	P(T<=t) one-tail		0.1506	P(T<=t) one-tail		0.1148
Shot Group at 7 yards	Mean	18.48	18.05	Mean	12.56	15.47	Mean	22.25	24.24
	sd	11.22	12.57	*sd*	4.28	8.35	*Sd*	8.14	10.68
	P(T<=t) one-tail		0.4614	P(T<=t) one-tail		0.1205	P(T<=t) one-tail		0.2902
Shot Group at 15 yards	Mean	32.64	37.33	Mean	24.73	29.99	Mean	42.65	38.75
	sd	13.79	27.23	*sd*	6.62	17.54	*Sd*	12.46	11.83
	P(T<=t) one-tail		0.2777	P(T<=t) one-tail		0.1447	P(T<=t) one-tail		0.2026

IV. SUMMARY, DISCUSSION, RECOMMENDATIONS, AND CONCLUSIONS

A. SUMMARY

This thesis examined how simulation-based marksmanship training, using ISMT, transfers to live fire compared to SNMT, and how long any beneficial training effects last. This research explored whether the use of simulation, combined with live fire, can provide a more robust method for conducting marksmanship training than SNMT. The research questions addressed in this thesis were: (1) Does ISMT accomplish skill transfer from the virtual environment to actual proficiency in marksmanship performance? (2) Can the ISMT be used as an effective part-task trainer to improve performance with the M9 on the NHQC? Specifically, will participants in the simulation group have a better chance of retaining what they learned after two weeks or four weeks of no instruction, than participants in the control group when doing live fire?

The experimental design for this thesis utilized a between-groups study of active duty military volunteers randomly selected to complete either control group or simulation group. Marksmanship performance was measured by MPI of group shots and scores on the NHQC. Prior to the first session, all participants completed a demographic survey containing questions that asked about the participants' characteristics, marksmanship skill level, and experience. The first session consisted of recording a baseline of their current level of marksmanship performance and score recorded via the ISMT before exposure to either training condition. Control groups received SNMT, and simulation groups received training using the feedback tools from ISMT. Both groups participated in an additional post-training simulation NHQC firing sequence. One control and simulation group did not receive any additional training for two weeks, while the other control and simulation group did not receive any additional training for four weeks. After their respective time lapse, all groups conducted a final live fire NHQC firing sequence to determine their retention of marksmanship skill.

B. HYPOTHESIS ONE DISCUSSION

$H0_1$: There will be no group differences in the participants' MPI of shots and scores in the NHQC firing sequence from baseline to live fire.

HA_1: Participants who receive simulation-based training in ISMT will have a greater improvement in MPI of shots and scores in the NHQC firing sequence when comparing the difference between baseline and live fire than participants who receive SNMT.

The analysis indicated that there were no significant differences in performance in scores or MPI between the simulation group and control group in any of the shooting events. Important details from this analysis will be discussed below.

1. Scores

Both the simulation and control groups significantly improved scores from baseline to live fire; however, there were no statistical differences rate of improvement between the two groups. Based on previous research results, which showed simulation training performed no worse than live training, the results of this portion of the analysis were not surprising. Score performance is dependent only on where each shot hits the Transtar II target and is not based on the grouping of shots. Examining the Transtar II target, region one yields zero points, region two yields two points, region three yields three points, region four yields four points, and regions five and six yield five points (see Figure 11). Although the comparison of difference scores between groups did not show statistical differences, it is important to note that the control group average baseline score was 201.44 ± 21.25 points, whereas the simulation group average baseline score was 210.33 ± 21.94 points. This difference is important because there is not as much room for improvement for the simulation group's score due to the maximum allowable score of 240 points. Indeed, 4 of the 15 simulation participants were close to the maximum score at baseline, compared to 2 of the 16 control participants. Thus, the trend for the control group to show greater improvement in their scores could be due to the

control group having more room to improve. A future study that more carefully matches the baseline marksmanship performance between simulation and control participants is necessary to investigate this suggestion.

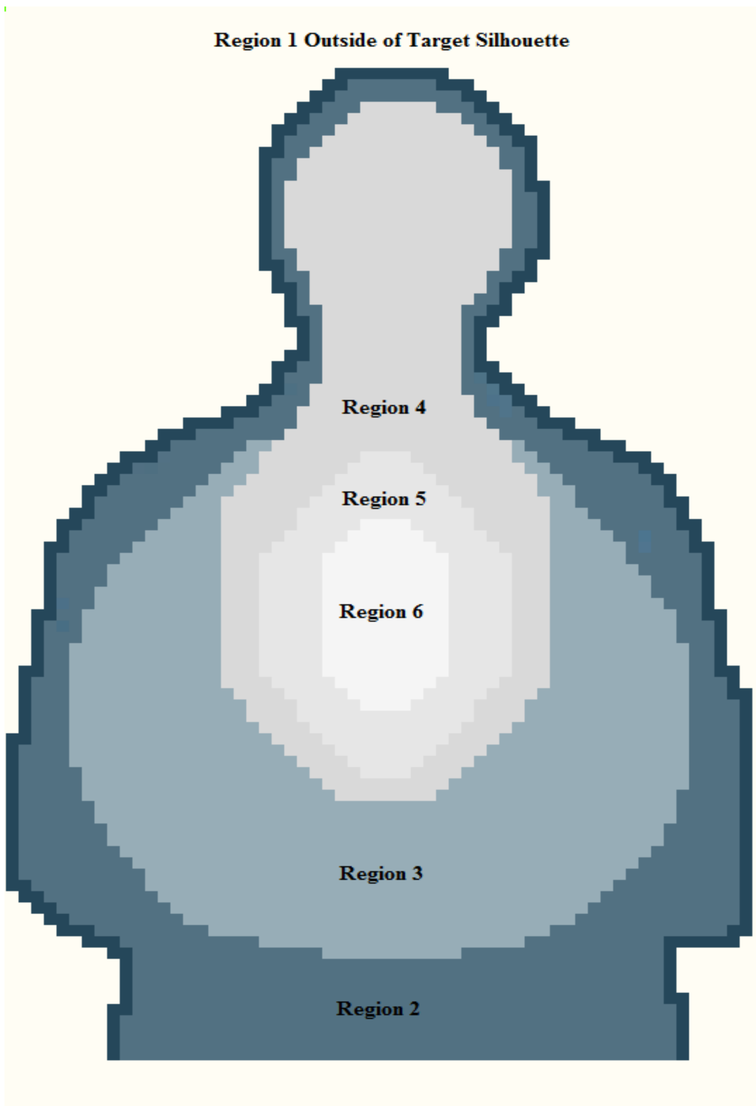

Figure 11. Transtar II Silhouette Target with Regions (From Getty, 2008)

2. MPI

The analysis indicated significant between group differences in change in the MPI performance from baseline to live fire in which the simulation group showed no

significant change in performance, but the control group showed degradation in MPI measurements.

Because regions five and six on the Transtar II target, approximately (30.8 cm tall and 20.6 cm wide) ellipse, are both scored as five points per shot, the score and MPI do not directly parallel each other in results. In other words, the MPI is a more fine-tuned measure of performance. The results suggest that the simulation group not only shot as well as the control group, but their MPI was less likely to deteriorate over time compared to the control group.

C. HYPOTHESIS TWO DISCUSSION

$H0_2$: Participants in each group will be equally likely to maintain their MPI of shots and scores on the NHQC two weeks and four weeks after the training day.

HA_2: Participants who receive simulation-based training in ISMT will be more likely than those in the control group to maintain their MPI of shots and scores in the NHQC two weeks and four weeks after the training day.

Hypothesis two was not able to be tested as written due to the small sample sizes for each condition. Instead, data from the training groups were combined and the main effects of time gap were assessed. Thus, the two-week group had seven simulation group participants and eight control group participants, and the four-week group had five simulation group participants and seven control group participants.

The analysis indicates that there was no significant difference in change in performance in scores or MPI from baseline to live fire between participants with a two-week gap from baseline to live fire than participants with a four-week gap. Important details from this analysis will be discussed below.

1. Scores and MPI

The analysis indicated that there were no significant differences found in the difference score and MPI between the two- and four-week gap groups from baseline to live fire. The results are not surprising given that Getty (2008) concluded that a one-week gap was not enough time to determine retention. The initial experimental design for this research was for shooters to have a live fire event the week following training,

followed by either a two- or four-month gap between the initial live fire event and a final live fire event. However, due to time constraints, the initial live fire event following training had to be removed and the time gaps between post-training and live were limited to two and four weeks.

The analysis of the two- and four-week time gaps was insufficient to show any skill degradation. We were unable to test whether there were training group x time gap interactions due to the small sample sizes. A future study that has adequate sample sizes for each of these conditions is needed to address this research question. Additionally, longer time gaps are required to detect degradation. Time gaps of 3 and 6 months or 6 and 12 months should be investigated.

D. EXPLORATORY ANALYSIS DISCUSSION

As noted in Chapter III, each shooter participated in an initial baseline shooting event, a post-training shooting event, and a final live fire shooting event. Exploratory analysis was conducted on the shot group diameter and MPI measurements and was recorded for each firing distance from the target (3, 7, and 15 yards).

1. Control Group to Simulation Group Comparisons at Each Distance From Target

a. MPI

The analysis indicated that the simulation group performed better than the control group at the 7- and 15-yard distances during post-training and at the 3-yard distance for live fire. These results suggest that ISMT training may be most beneficial for the 7- and 15-yard distances and simulation to live fire training transfer occurred for the 3-yard distance. These results pinpoint the distances in which simulation training appears to be more beneficial than SNMT.

b. Shot Group Diameter

The analysis indicated no significant differences at any distance from the target between the simulation and control groups for shot-group diameter.

2. Two- and Four-Week Gaps Between Post-Training and Live Fire Comparisons at Each Distance From Target

a. MPI

The analysis indicated significant differences in MPI for the three-yard distance in the baseline, with the four-week gap group having a smaller MPI than the two-week gap group. This result was surprising given the expectation of performance degradation over time. Also, for the change in MPI from baseline to live fire comparison at the 3-yard distance, the two-week gap group maintained their MPI better than the four-week gap group. As stated above, larger sample sizes are needed to assess a training group by time gap interaction effect. For example, this result may be due to the simulation group showing steady MPI performance at both two weeks and four weeks, whereas the control group showed degradation at four weeks.

b. Shot Group Diameter

The analysis indicated no significant differences at any distance from the target between the simulation and control groups for shot-group diameter.

E. FUTURE WORK AND RECOMMENDATIONS

This research originally contained two live fire events, but due to time constraints, the research design was modified to incorporate only one live fire event. A future study should follow the original design of this research to include a pre-training demographic questionnaire and a baseline shooting event in ISMT of all participants, followed by experimental training in ISMT with a post-training shooting event in ISMT and control training using SNMT with a post-training shooting event in ISMT. The week following completion of training, both experimental and control groups should complete a live fire shooting event using the NHQC firing sequence. After the initial live fire event, a longer time gap (i.e., 2- and 4-month, 3- and 6-month, or 6- and 12-month gap) than what was used in this research could be beneficial. In addition, using a larger sample size of participants could yield more definitive data, particularly regarding the time gap results.

A future study also should explore whether simulation marksmanship training is more likely to reduce the effects of performance anxiety in a live fire shooting event than

SNMT. Chung, Delacruz, Vries, Bewley, and O'Neil (2005) found that anxiety had a significant negative effect on marksmanship performance. Their goal was to measure how anxiety affected novice shooters' performance and to what degree anxiety contributed to the prediction of performance above and beyond aptitude. They used the annual qualification of Marines in rifle marksmanship as the event, since the qualification is extremely stressful for the participating Marines because individual scores directly affect promotion. The annual qualification consists of a week of instruction and practice, culminating on the last day with the final qualification. The importance of this study was clear when the final qualification indicated that overall state anxiety and state worry were negatively correlated with firing line experience. Participants who had higher levels of anxiety also had higher levels of worry. Participants who had a more positive firing line experience had lower anxiety and worry. A research design similar to this study should be used, while also incorporating both self-report and physiological measures of anxiety, such as heart rate and galvanic stress response during the ISMT shooting event and live fire shooting event. A supplement to questionnaires would include monitoring heart rate during the ISMT shooting event and live fire shooting event.

During the course of this research, only one weapon malfunction occurred compared to nine weapons malfunctions experienced by Getty (2008). The lower number of malfunctions may be attributed to shutting down the ISMT system between participants and allowing the laser inside each weapon to cool. By minimizing weapons malfunctions, this eliminated prolonged down time of ISMT while a new weapon was shipped to NPS.

F. CONCLUSION

The results of this research indicates that: (1) simulation training leads to marksmanship performance no worse than SNMT regarding scores and (2) simulation training leads to marksmanship performance that is better than SNMT regarding MPI. MPI provides a more accurate measure of marksmanship performance than score and, therefore, may be more indicative of how well a watchstander would perform in an actual threat situation. ISMT provides a medium of training that is more versatile than live training in that it can be accomplished in any weather conditions because it is an indoor

trainer. The Navy's use of ISMT onboard ships would provide the means for Sailors and Marines to practice a perishable skill, such as marksmanship, regardless of weather, ship schedule, or operational commitments while underway. These factors often inhibit live fire training. Having an ISMT onboard ship also would allow Sailors and Marines to meet the current sustainment training requirement of eight months and could allow extra training, with a substantially reduced cost compared to live fire training. Personnel could train and practice often, honing marksmanship skills, while ultimately providing better-trained watchstanders and increasing the marksmanship skills of ships security force.

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